Regional Routing Model Review:

C) Model Formulation and Scenario Analysi

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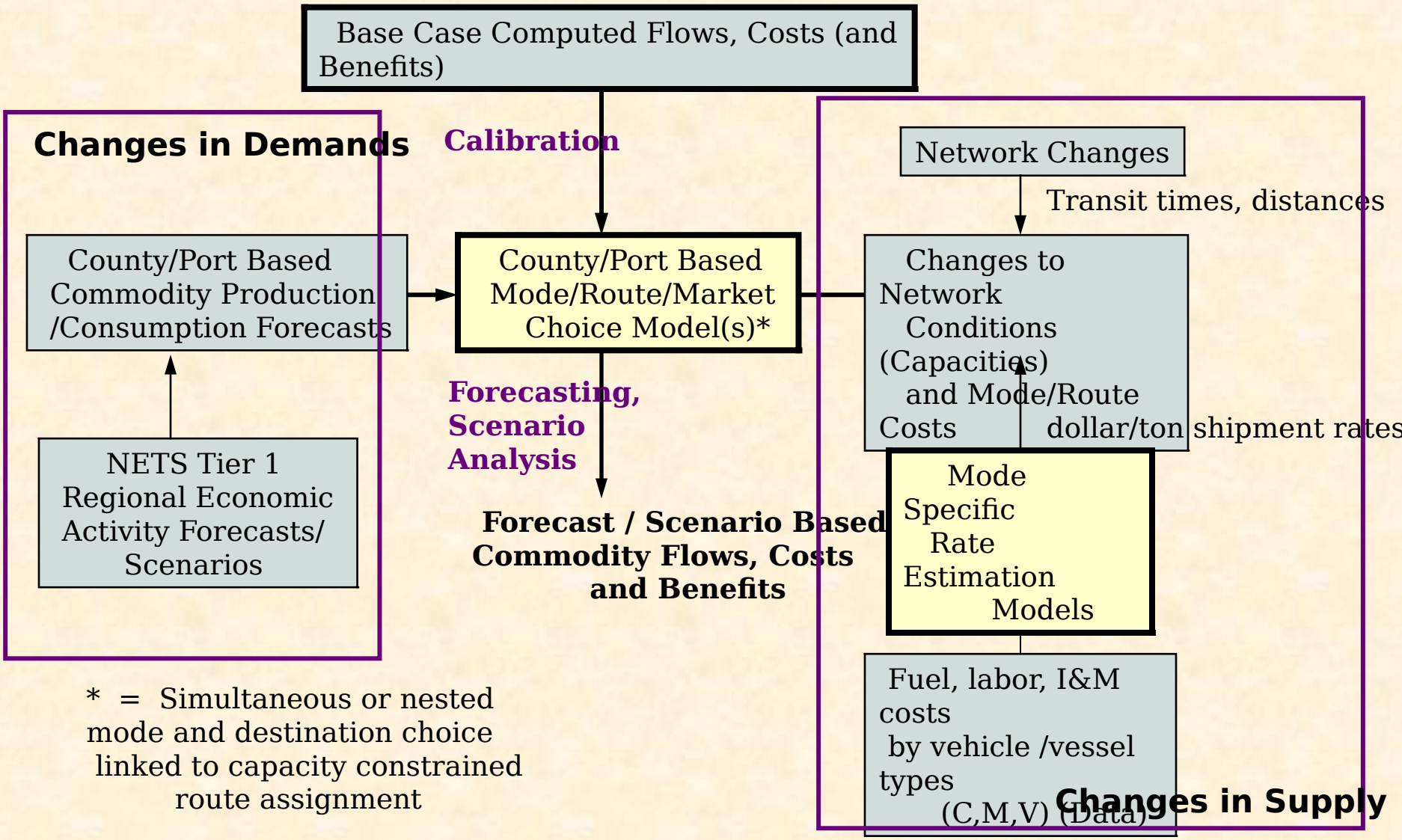
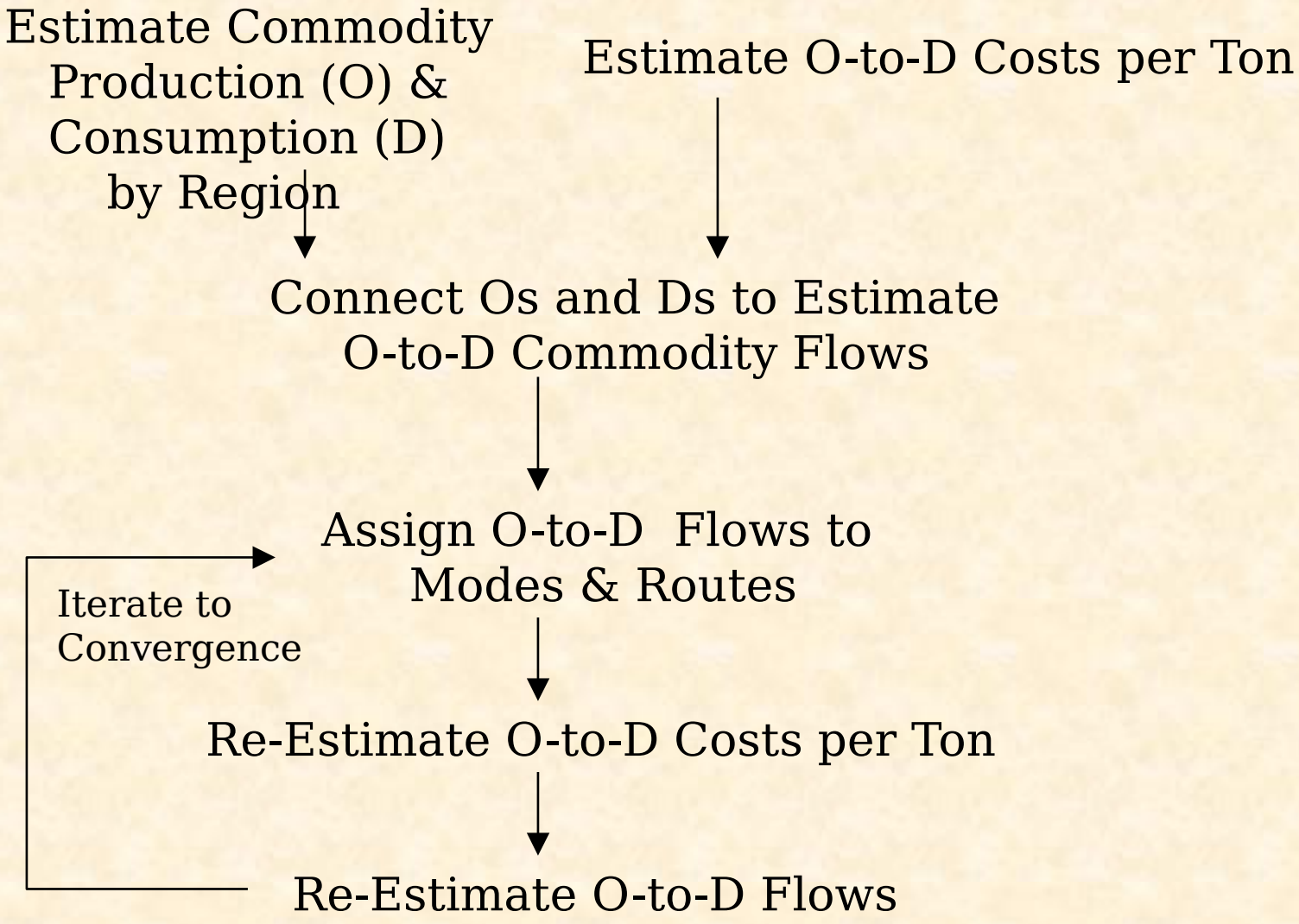
U. S. DEPARTMENT OF ENERGY

Calibration, Forecasting & Scenario Analysis


Base Case Computed Flows, Costs (and Benefits)
Changes in Demands
Calibration
Network Changes
Transit times, distances
County/Port Based Commodity Production /Consumption Forecasts
County/Port Based Mode/Route/Market Choice Model(s)*
Changes to Network Conditions (Capacities) and Mode/Route Costs
dollar/ton shipment rates
NETS Tier 1 Regional Economic Activity Forecasts/ Scenarios
Forecasting, Scenario Analysis
Mode Specific Rate Estimation Models
Forecast / Scenario Based Commodity Flows, Costs and Benefits
Fuel, labor, I&M costs by vehicle /vessel types (C,M,V) (Data)
Changes in Supply

* = Simultaneous or nested mode and destination choice linked to capacity constrained route assignment

The Basic Flow and Cost Estimation Process


Estimate Commodity Production (O) & Consumption (D) by Region
Estimate O-to-D Costs per Ton
Connect Os and Ds to Estimate O-to-D Commodity Flows
Assign O-to-D Flows to Modes & Routes
Iterate to Convergence
Re-Estimate O-to-D Costs per Ton
Re-Estimate O-to-D Flows

Prototype Regional Routing Model Formulation:

$$\underset{V,X}{Minimize}\ Z(V,X) = \sum_{ak} \int_{0}^{Vak} S^{ak}(\omega)\,d\omega + \sum_{m} 1/\beta^{m} \left(X_{ij}^{m} \ln X_{ij}^{m} \right) + \sum_{m} 1/\lambda^{m} \left(X_{ij}^{km} \ln X_{ij}^{km} \right)$$

subject to:

$V^{ak} = \sum_{i} \sum_{j} \sum_{r} \delta_{i,j}^{akr} X_{ij}^{kr}$ for all links, a, and modes k, in the network

$\sum_{r} X_{ij}^{rk} = X_{ij}^{k}$ for i=1,2,...I, and j=1,2,...J

$\sum_{k} X_{ij}^{k} = X_{ij}$ for i=1,2,...I, and j=1,2,...J

$V^{ak} \geq 0$

$X_{ij}^{kr} \geq 0$

V = a link volume
X = an O-D flow volume
S = link transportation time or generalized cost

Freight Destination Choice (Flows Modeling):

$$X_{ij}^{m} = O_i^{m} \; D_j^{m} \; F[\beta^{m} c_{ij}^{m}] \; A_i^{m} \; B_j^{m}$$

where

$$A_i^{m} = 1/\{\Sigma_j B_j^{m} D_j^{m} F[\beta^{m} c_{ij}^{m}]\} \quad \text{for all } i$$

$$B_j^{m} = 1/\{\Sigma_i A_i^{m} O_i^{m} F[\beta^{m} c_{ij}^{m}]\} \quad \text{for all } j$$

and

$$\Sigma_{ij} \{ X_{ij}^{m} d_{ij}^{m} \} / \Sigma_{ij} X_{ij}^{m} = \bar{d}^{*m}$$

Freight Mode Choice:

$$X_{ij}^{km} = X_{ij}^{m} * [\exp(-\theta^{m} \; c^{km}) / \sum_{k \varepsilon K(m)} \exp(-\theta^{m} \; c^{km})]$$

where (for example):

$$c_{ij}^{km} = \alpha 0 \; + \alpha 1 \; r_{ij}^{km} \; + \alpha 2 \; S_{ij}^{km} \; + \alpha 3 \; v_{ij}^{km}$$

and,

$$\overline{c}_{ij}^{m} = -(1/\lambda^{m}) \; \ln \; \{\Sigma_{k} \; \exp(-\lambda^{m} \; c_{ij}^{km})\}$$

(links mode and destination choice)

Components of Freight Costs that Need Modeling:

Number of different "legs" to a journey

Shipper/receiver perceived costs per leg:

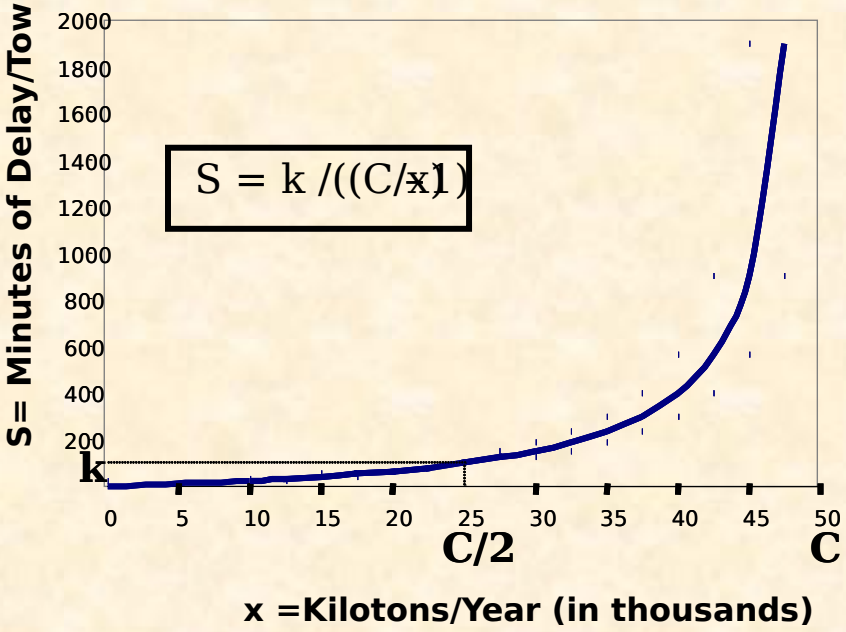
- **freight rate**
- **transit time**
- **service reliability**

Congestion effects

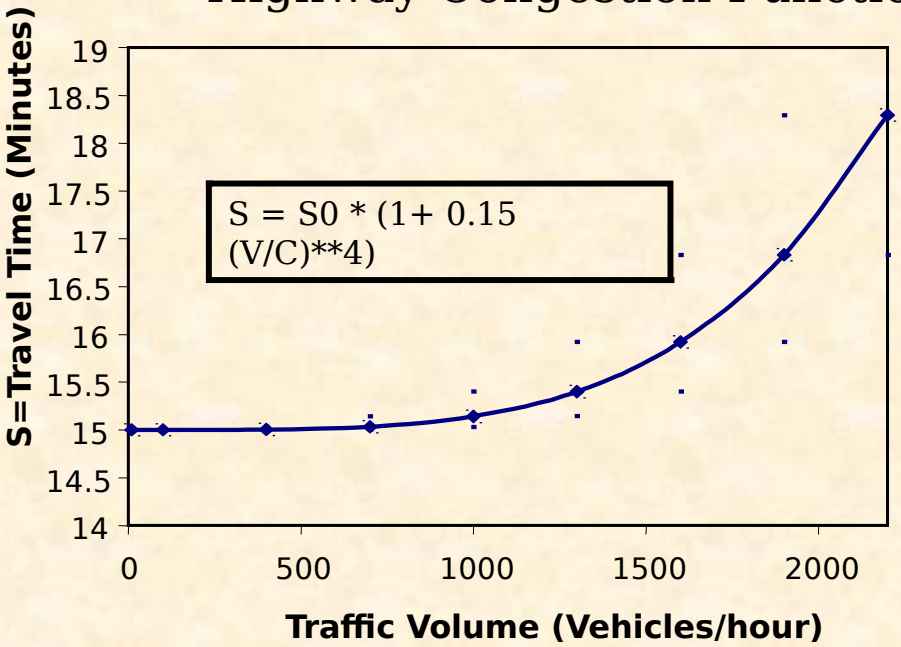
- **i.e. congestion → transit time and reliability → direct plus indirect (i.e. rate) effects on costs**

Network Link Transit Time (Congestion) Functions

Lock Congestion Function



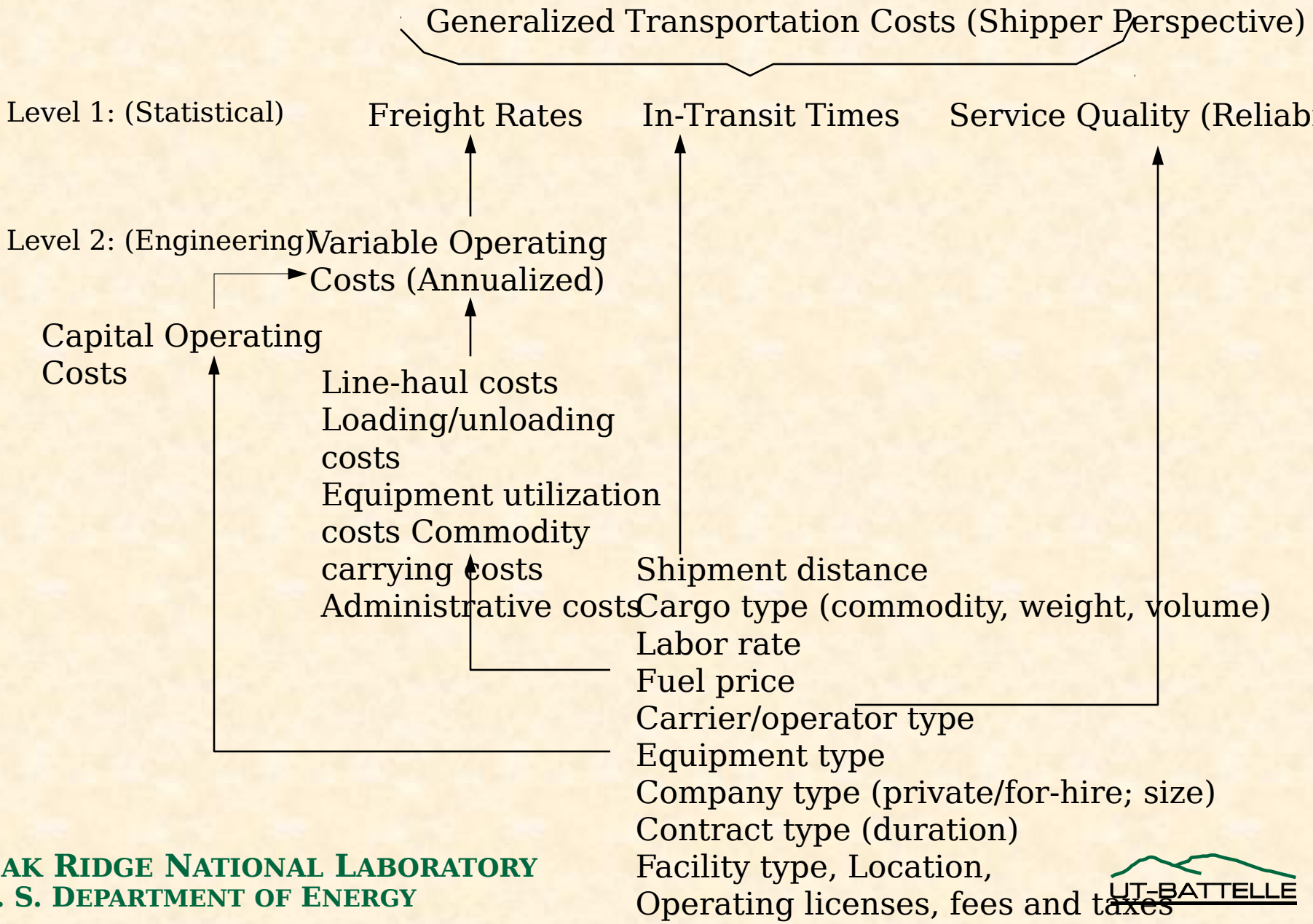
Highway Congestion Function

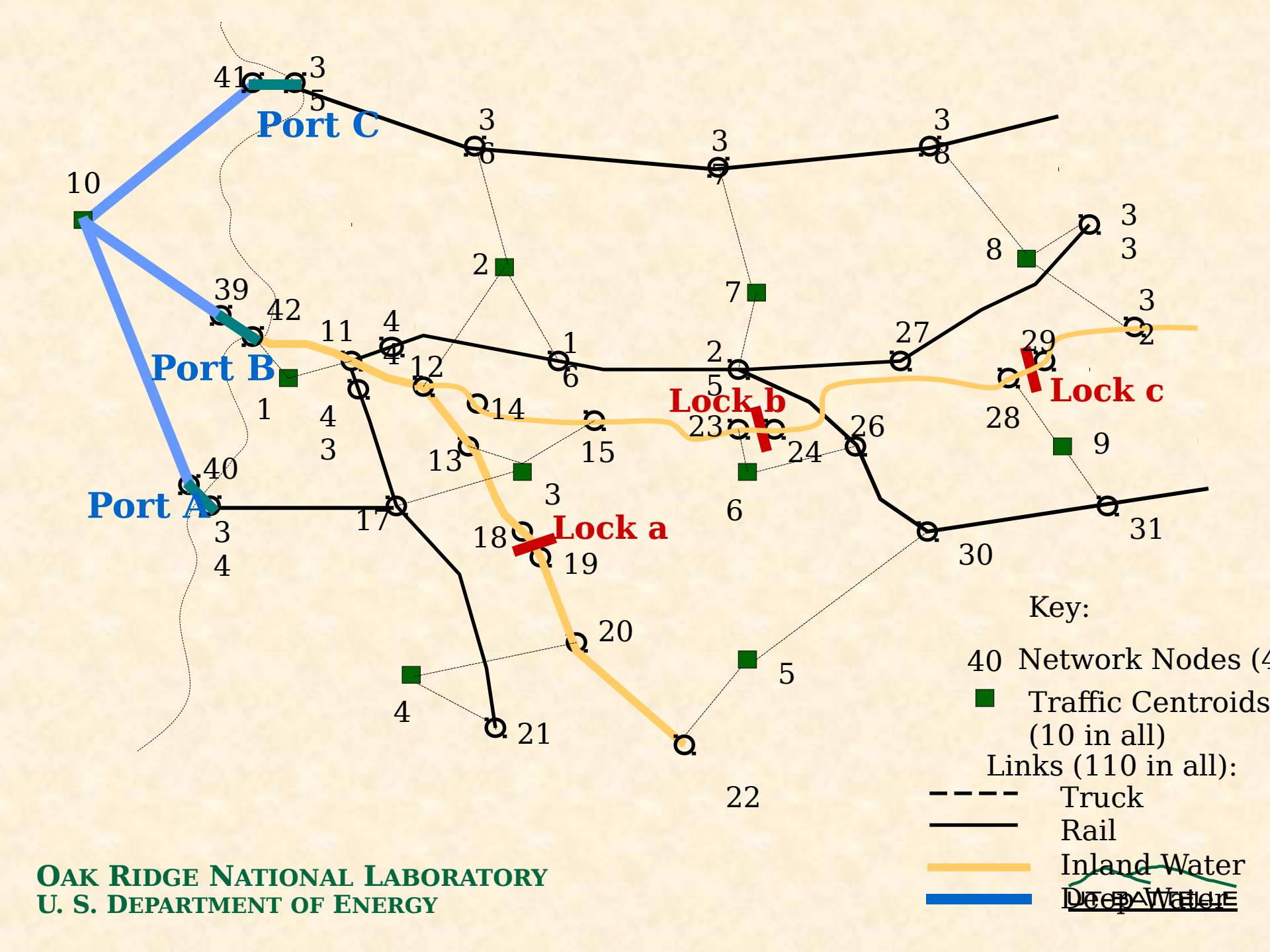


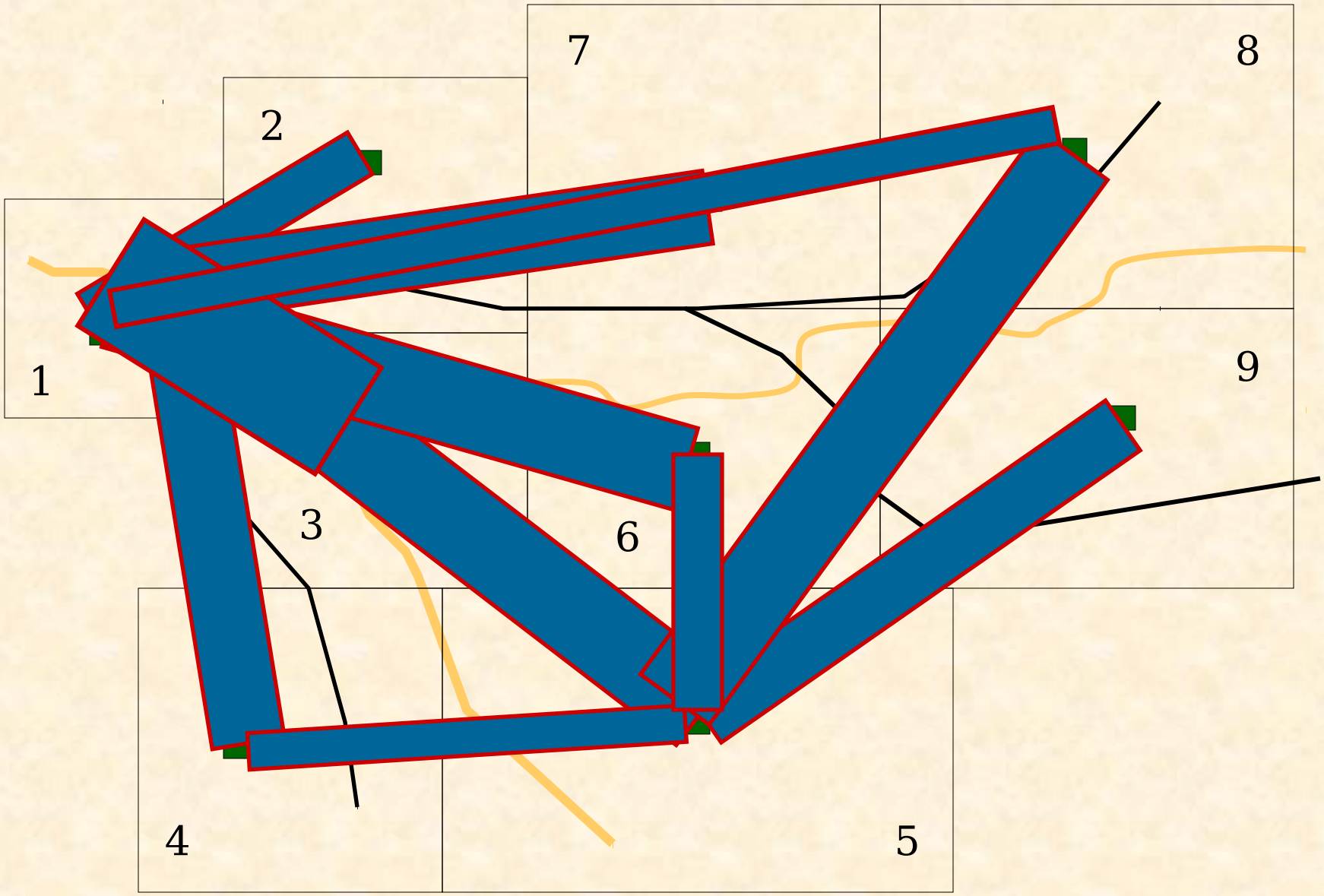
"Generic" link congestion function for use in Toy Model:

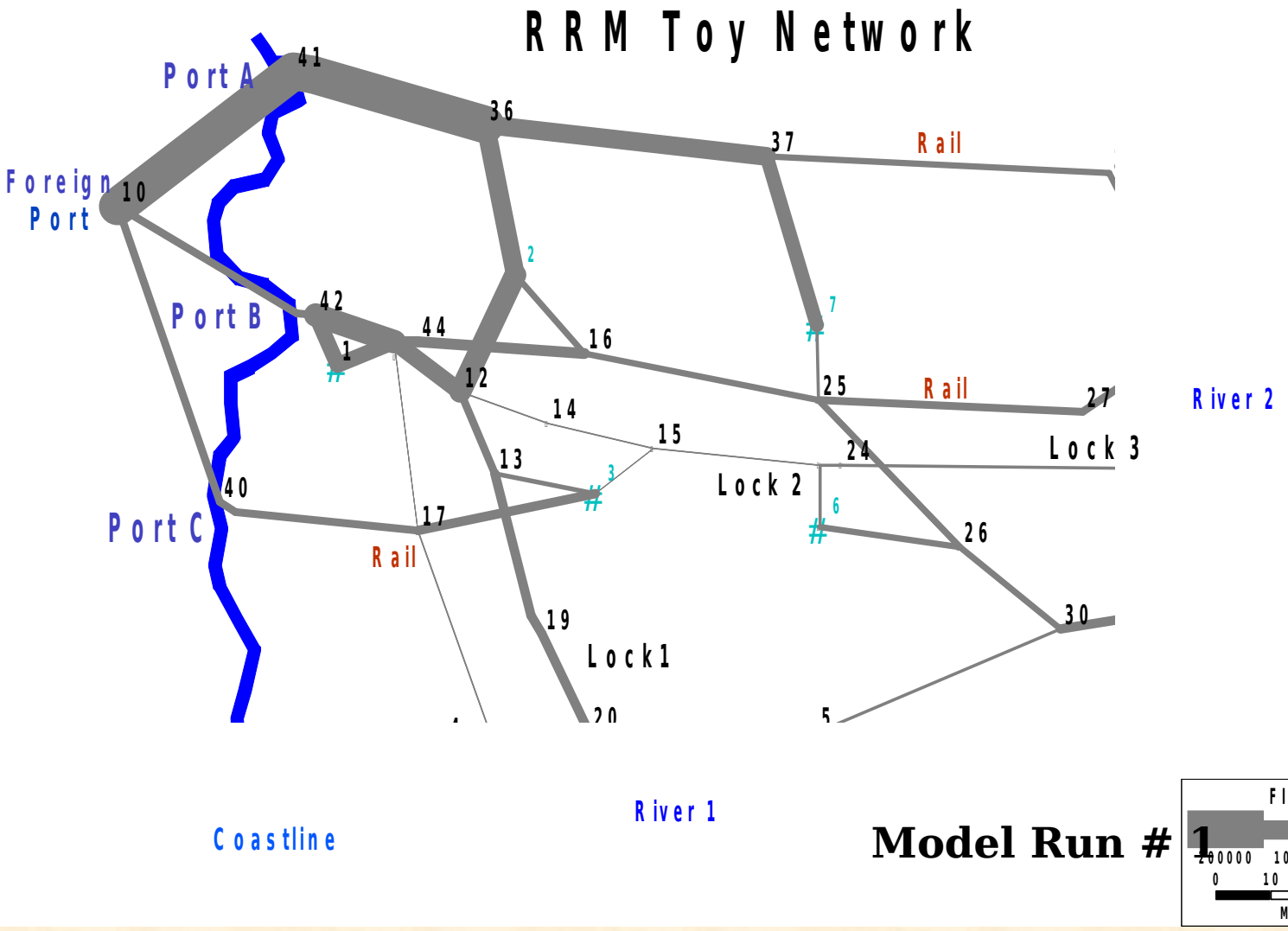
$$S_a = S_{ao} * [\, 1 + \theta 1 * V_a + \theta 2 * (\, V_a / Cap_a)^{\gamma}$$

Components of Freight Movement Costs

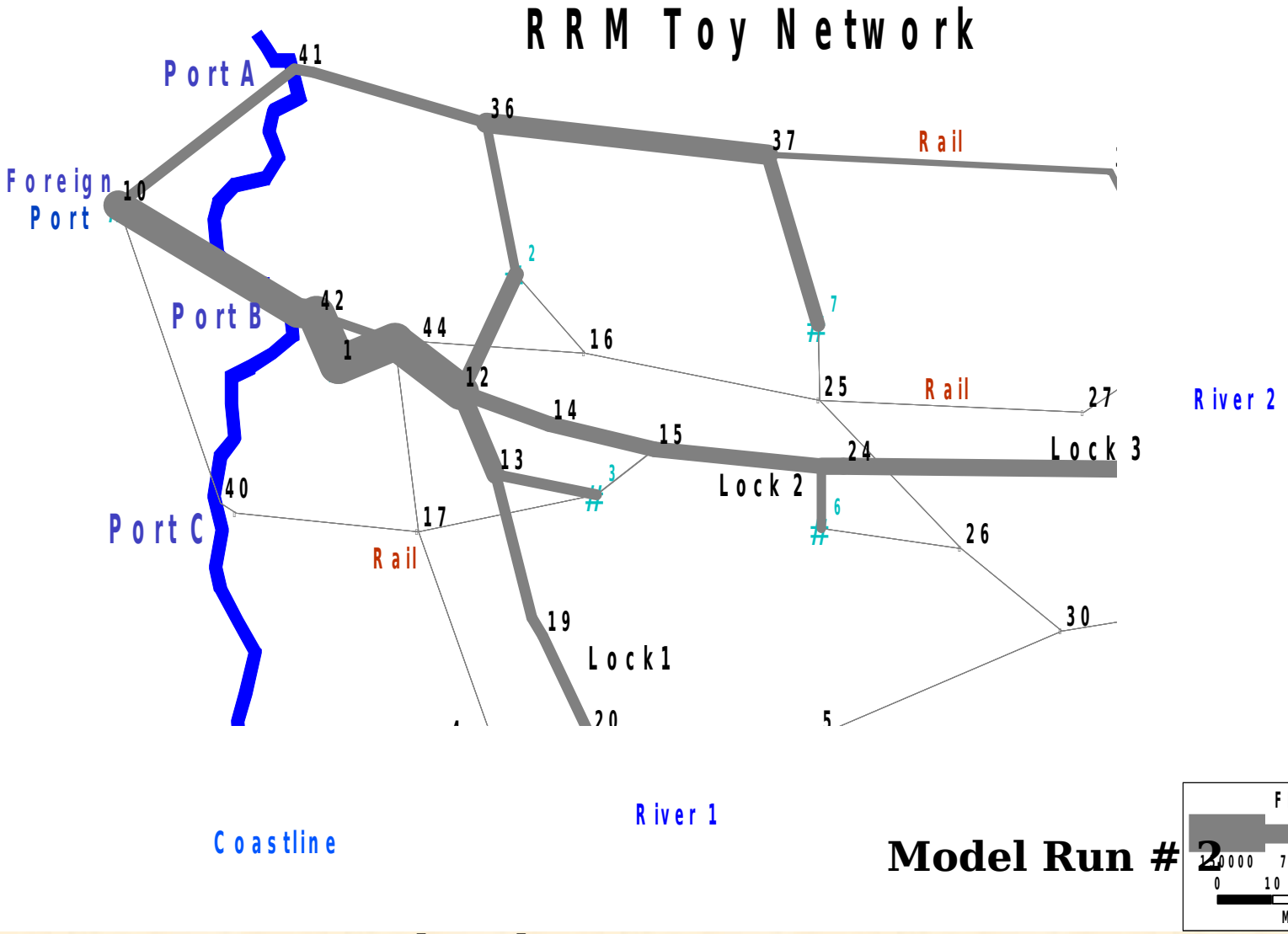



Port C
Port B
Port A
Lock a
Lock b
Lock c
Key:
40 Network Nodes (4
Traffic Centroids
(10 in all)
Links (110 in all):
Truck
Rail
Inland Water
Deep Water


7
8
2
1
9
3
6
4
5



Origin Mode Split = 36.7% water
63.3 % rail



Model Run # 2

Origin Mode Split = 74.9% water
25.1% rail

Destination Flow Comparisons